Claims

What is claimed is:

1. A method for implementing a next generation synchrotron light source comprising the steps of:

providing first electron beam source modules for producing a first electron beam;

providing initial electron beam source modules for producing multiple harmonic wavelength photons;

combining said multiple harmonic wavelength photons with said first electron beam;

providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam to be used as the next generation synchrotron light source or as a coherent seed for additional selected modules.

2. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing initial electron beam source modules for producing multiple harmonic wavelength photons includes the steps of providing an electron gun and an accelerating structure for producing an electron beam; said accelerating structure receiving emitted electrons from said electron gun and raising electron beam energy.

3. A method for implementing a next generation synchrotron light source as recited in claim 2 wherein the step of providing initial electron beam source modules for producing multiple harmonic wavelength photons further includes the steps of providing an electron bunch compressor for prebunching said electron beam to increase an electron bunch peak current, providing a seed laser beam and coupling in an undulator said seed laser beam with said prebunched electron beam.

4. A method for implementing a next generation synchrotron light source as recited in claim 3 wherein the step of providing initial electron beam source modules for producing multiple harmonic wavelength photons further includes the steps of providing a radiation production section receiving said seed laser beam coupled with said prebunched electron beam for producing multiple harmonic wavelength photons.

5. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing first electron beam source modules for producing said first electron beam includes the steps of providing an electron gun, an electron accelerating structure coupled to said electron gun and an electron bunch compressor coupled to said electron accelerating structure for producing said first electron beam.

6. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam includes the steps of providing a first amplifier module and a second amplifier module coupled to said first amplifier module; applying a seed laser beam λ_{fund} and a first electron beam to said first amplifier module; generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said first amplifier module; and applying a second electron beam and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ to said second amplifier module that is used as a coherent seed for said second amplifier module; and generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said second amplifier module.

7. A method for implementing a next generation synchrotron light source as recited in claim 6 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam further includes the steps of providing a third amplifier module coupled to said second amplifier module and a fourth amplifier module coupled to said third amplifier module; applying a third electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said second amplifier module to said third amplifier module that is used as a coherent seed for said third amplifier module; generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said third amplifier module; and applying a fourth electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said third amplifier module to said fourth amplifier module that is used as a coherent seed for said fourth amplifier module; and generating fundamental and said predefined nonlinear harmonics in said fourth amplifier to be used as the next generation synchrotron light source.

8. A method for implementing a next generation synchrotron light source as recited in claim 6 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam includes the steps of providing a high-gain harmonic generation (HGHG) module; said HGHG module including a modulative section, a dispersive section and a radative section; applying a third electron beam and said generated fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ from said second amplifier module to said high-gain harmonic generation (HGHG) module.

9. A method for implementing a next generation synchrotron light source as recited in claim 8 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam further includes the steps of generating fundamental and said predefined nonlinear harmonic in said high-gain harmonic generation (HGHG) module to be used as the next generation synchrotron light source.

10. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam includes the steps of providing a first amplifier module and a high-gain harmonic generation (HGHG) module coupled to said first amplifier module; applying a seed laser beam λ_{fund} and a first electron beam to said first amplifier module; generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said first amplifier module; and applying a second electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said first amplifier module to said high-gain harmonic generation (HGHG) module that is used as a coherent seed for said high-gain harmonic generation (HGHG) module.

11. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam further includes the steps of generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said high-gain harmonic generation (HGHG) module to be used as the next generation synchrotron light source.

12. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam includes the steps of providing a first high-gain harmonic generation (HGHG) module and a second high-gain harmonic generation (HGHG) module coupled to said first high-gain harmonic generation (HGHG) module; applying a seed laser beam λ_{fund} and a first electron beam to said first high-gain harmonic generation (HGHG) module; generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said first high-gain harmonic generation (HGHG) module; and applying a second electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ to said second high-gain harmonic generation (HGHG) module that is used as a coherent seed for said second high-gain harmonic generation (HGHG) module; and generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$ in said second high-gain harmonic generation (HGHG) module to be used as the next generation synchrotron light source.

13. A method for implementing a next generation synchrotron light source as recited in claim 1 wherein the step of providing selected radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam includes the steps of providing selected radiation production modules for producing the next generation synchrotron light source by a three step process including imprinting, upconverting or wavelength shifting and reinforcing or strengthening of said combined electron beam.

14. A method for implementing a next generation synchrotron light source as recited in claim 13 wherein the steps of imprinting of said combined electron beam includes the steps of receiving a seed laser beam and a first electron beam in an undulator for providing a specified amount of energy modulation and using a bunch compressor for overbunching of said electron beam.

15. A method for implementing a next generation synchrotron light source as recited in claim 14 wherein the step of upconverting or wavelength shifting of said combined electron beam includes the steps of applying said overbunched electron beam to an accelerating section to induce an energy chirp to said electron beam; and compressing said electron beam using a second bunch compressor.

16. A method for implementing a next generation synchrotron light source as recited in claim 15 wherein the step of reinforcing or strengthening of said combined electron beam includes the steps of removing said energy chirp from said electron beam in a second accelerating section; injecting said resulting electron beam to a radiation production module to use harmonic content of said electron beam.

17. A method for implementing a next generation synchrotron light source as recited in claim 16 wherein the step of injecting said electron beam to a radiation production module includes the step of injecting said resulting electron beam into an undulator (amplifier), two-undulator harmonic generation schemes (TUHGS) or a high-gain harmonic generation (HGHG) module.

18. A modular system for implementing a next generation synchrotron light source comprising:

first electron beam source modules for producing a first electron beam;

initial electron beam source modules for producing multiple harmonic wavelength photons;

a mixer for combining said multiple harmonic wavelength photons with said first electron beam;

radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam to be used as the next generation synchrotron light source or as a coherent seed for additional selected modules.

19. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a seed laser providing a seed laser beam λ_{fund} and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include four amplifier modules connected in series, each of said four amplifier modules tuned to a fundamental resonance; said seed laser beam λ_{fund} and said first electron beam applied to a first amplifier module of said four series connected amplifier modules; said first amplifier module generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a second electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said first amplifier module applied to a second amplifier module and used as a coherent seed for said second amplifier module; said second amplifier module generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a third electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said second amplifier module applied to a third amplifier module and used as a coherent seed for said third amplifier module; said third amplifier module generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$; and a fourth electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said third amplifier module applied to a fourth amplifier module and used as a coherent seed for said fourth amplifier module; said fourth amplifier module generating fundamental λ_{fund} and nonlinear harmonics $\lambda_{predefined}$ used as the next generation synchrotron light source.

20. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a seed laser providing a seed laser beam λ_{fund} and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include a first high-gain harmonic generation (HGHG) module and a second high-gain harmonic generation (HGHG) module connected in series; said seed laser beam λ_{fund} and said first electron beam applied to said first high-gain harmonic generation (HGHG) module; said first high-gain harmonic generation (HGHG) module inducing energy modulation and spatial bunching in respective modulative and radiative sections; said first high-gain harmonic generation (HGHG) module generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a second electron beam and a predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said first high-gain harmonic generation (HGHG) module applied to said second high-gain harmonic generation (HGHG) module; and said second high-gain harmonic generation (HGHG) module producing a longitudinally coherent output radiation in said fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{predefined}$ used as the next generation synchrotron light source.

21. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a seed laser providing a seed laser beam λ_{fund} and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include a first amplifier module and a second amplifier module connected in series and a high-gain harmonic generation (HGHG) module connected to said second amplifier module; said seed laser beam λ_{fund} and said first electron beam applied to said first amplifier module; said first amplifier module generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a second electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said first amplifier module applied to said second amplifier module and used as a coherent seed for said second amplifier module; said second amplifier module generating fundamental λ_{fund} and said predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a third electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said second amplifier module applied to said high-gain harmonic generation (HGHG) module; said high-gain harmonic generation (HGHG) module including a modulative section to induce predefined energy modulation in said third electron beam; and a radiative section tuned to said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said second amplifier module and producing a longitudinally coherent output radiation in said predefined nonlinear harmonic $\lambda_{predefined}$ used as the next generation synchrotron light source.

22. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a soft x-ray seed laser providing a seed laser beam λ_{fund} and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include an amplifier module and a high-gain harmonic generation (HGHG) module connected to said amplifier module; said seed laser beam λ_{fund} and said first electron beam applied to said amplifier module; said amplifier module generating fundamental λ_{fund} and a predefined nonlinear harmonics $\lambda_{seed(predefined)}$; a second electron beam and said predefined nonlinear harmonic $\lambda_{seed(predefined)}$ from said first amplifier module applied to said high-gain harmonic generation (HGHG) module; said high-gain harmonic generation (HGHG) module producing a longitudinally coherent output radiation in said predefined nonlinear harmonic $\lambda_{predefined}$ used as the next generation synchrotron light source.

23. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a soft x-ray seed laser providing a seed laser beam λ_{fund} and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include selected radiation production modules for producing the next generation synchrotron light source including functions for imprinting, upconverting or wavelength shifting and reinforcing or strengthening of said combined electron beam.

24. A modular system for implementing a next generation synchrotron light source as recited in claim 23 wherein said imprinting function for imprinting of said combined electron beam includes an undulator for receiving a seed laser beam and a first electron beam and for providing a specified amount of energy modulation and a bunch compressor for overbunching of said electron beam; wherein said upconverting or wavelength shifting function includes an accelerating section receiving said overbunched electron beam to induce an energy chirp to said electron beam; and a second bunch compressor compressing said electron beam; and wherein said reinforcing or strengthening function for reinforcing or strengthening of said combined electron beam includes a second accelerating section for removing said energy chirp from said electron beam; a radiation production module receiving said resulting electron beam to use harmonics of said electron beam.